NUMERICAL PHYSICS

9TH CLASS

Presented by:

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NUMERICAL PROBLEMS

10.1 The time period of a simple pendulum is 2s. What will be its length on Earth? What will be its length on the moon if $g_m = g_e / 6$? Where $g_e = 10 ms^{-2}$.

Solution:

Given Data:-

Time period of simple pendulum = t = 2 sec. The gravitation all acceleration on earth as well as on moon should be included in given data.

Required:-

(i) Length of pendulum on earth = l_e = ?

(ii) Length of pendulum on moon = l_m = ?

Formula:-

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Solution:-

(i) **For Earth**

$$T = 2\pi\sqrt{\frac{l_e}{g_e}}$$

By taking square on both sides, we have

$$T^2 = 4\pi^2\frac{l_e}{g_e}$$

or

$$l_e = \frac{T^2 \times g_e}{4\pi^2}$$

By putting the values, we have

$$l_e = \frac{(2)^2 \times 10}{4 \times (3.14)^2}$$

$$l_e = \frac{4 \times 10}{4 \times 9.86}$$

$$l_e = 1.02m$$

(ii) **For Moon**

$$T^2 = \frac{4\pi^2 l_m}{g_m}$$

$$l_m = \frac{T^2 g_m}{4 \times \pi^2}$$

By putting the values, we have

$$l_m = \frac{(2)^2 \times 1.6}{4 \times (3.14)^2} = \frac{6.44}{39.44}$$

$$l_m = 0.17m$$

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نوٹ: ہمارے کسی گروپ کی کوئی فیس نہیں ہے۔ سب فی سبیل اللہ ہے

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اللہ تبارک تعالیٰ ہم سب کا حامی و ناصر ہو

Result:-

Length of pendulum on earth = l_e = 1.02 m

Length of pendulum on moon = l_m = 0.17 m

10.2 A pendulum of length 0.99 m is taken to the moon by an astronaut. The period of the pendulum is 4.9s. What is the value of g on the surface of the moon?

Solution:

Given data:

Length of pendulum on moon = l_m = 0.99m

Time period = 4. 9sec

To Find:

Value of g on moon = g = ?

Formula:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Calculation:

$$4.9sec = 2\times 3.14\sqrt{\frac{0.99}{g}}$$

Squaring

$$g = \frac{4\times(3.14)^2\times 0.99}{(4.9)^2}$$

$g = 1.63\ ms^{-2}$

Result:

Value of g on moon = g = $1.6\ ms^{-2}$

10.3 Find the time periods of a simple pendulum of 1 meter length, placed on Earth and on moon. The value of g on the surface of moon is 1/6th of its value on Earth. When g_e is $10ms^{-2}$.

Solution:

Given data:

Length of pendulum = l = 1m

Value of g on earth = $10\ ms^{-2}$

Value of g on moon = $1.62\ ms^{-2}$

To find:

Time period on earth = T_e = ?

Time period on moon = T_m = ?

Formula:

Calculation:

At Earth:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T_e = 2(3.14)\sqrt{\frac{1}{10}}$$

$T_e = (6.28)\ \sqrt{0.1}$

$T_e = (6.28)\ (0.316)$

$T_e = 1.985$ sec.

$T_e = 2$sec. Ans

At Moon:

$$T_m = 2\pi\sqrt{\frac{l_m}{g_m}}$$

$$T_m = 2(3.14)\ \sqrt{\frac{1}{1.67}}$$

$$T = 2(3.14)\sqrt{0.6172}$$

$T = 4.9$ sec

Results:

Time period on earth $= T_e = 2$sec

Time period on moon $= T_m = 4.9$ sec

10.4 A simple pendulum completes one vibration in two seconds. Calculate its length when g = 10.0 ms^{-2}.

Solution:

Given data:

Time period = T = 2sec

g = 10 ms^{-2}

To Find:

Length of simple pendulum = L = ?

Calculation:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Squaring on both sides

$$T^2 = 4\pi^2 \times \frac{l}{g}$$

$$l = \frac{T^2 g}{4\pi^2}$$

$$l = \frac{(2)^2 \times 10}{4 \times (3.14)^2}$$

$$l = \frac{\cancel{4} \times 10}{\cancel{4} \times 9.85}$$

$l = 1.02$ m

Result:

Length of simple pendulum = l = 1.02 m

10.5 If 100 waves pass through a point of a medium in 20 seconds, what is the frequency and the time period of the wave? If its wavelength is 6cm, calculate the wave speed.

Solution:

Given data:

No. of waves = 100

Time = 20s

Wavelength = λ = 6cm = 0.06 m

Required:

Wave speed=v=?

Formula:

$$f = \frac{1}{T}$$

$$f = \frac{100}{20}$$

$$f = 5Hz$$

$$T = \frac{1}{f}$$

$$T = \frac{1}{5Hz}$$

$$T = 0.2 \text{ sec}$$

$$V = ?$$

$$V = f\lambda$$

$$V = 5 \times 0.06$$

$$V = 0.3 \text{ ms}^{-1}$$

10.6 A wooden bar vibrating into the water surface in a ripple tank has frequency of 12Hz. The resulting wave has a wavelength of 3cm. What is the speed of the wave?

Solution:

Given data:

Frequency f = 12 Hz

Wavelength = λ = 3cm = 0.03 m

Required:

Speed of wave = v = ?

Formula:

$$V = \lambda f$$

Calculations:

$$v = (0.03)(12)$$

$$V = 0.36 \text{ m/s}$$

Results:

Speed of wave is 0.36 m/s

10.7 A transverse wave produced on a spring has a frequency of 190 Hz and travels along the length of the spring of 90m, in 0.5s.

(a) What is the period of wave?

(b) What is the speed of the wave?

(c) What is the wavelength of the wave?

Solution:

Given data:

Frequency = f = 190 Hz

Length = ℓ = 90 m

Time = t = 0.5s

Required:

(i) Time period of wave = T = ?

(ii) Speed of wave = V = ?

(iii) Wavelength of wave = λ = ?

Calculations:

(i) Time period:

$T = 1/f$

$T = 1/190$

$T = 0.005$

$T = 0.01s$

(ii) Speed of wave:

$V = d/t$

$V = 90/0.5$

$V = 180$ m/s

(iii) Wavelength:

$\lambda = v/f$

$\lambda = 180/190$

$\lambda = 0.95$ m

Results:

Time period is 0.01s; speed of wave is 180 m/s and wavelength of wave is 0.95 m

10.8 Water waves in a shallow dish are 6.0 cm long. At one point, the water moves up and down at a rate of 4.8 oscillations per second.

(a) What is the speed of the water waves?

(b) What is the period of the water waves?

Given data:

Length of wave = d = 6.0 cm = 0.06 m

Frequency = f = 4.8 Hz

Required:

(i) Speed of waves = ? (ii) period of waves = ?

Calculations:

(i) Time period:

$T = 1/f$

$T = 1/4.8$

$T = 0.21$ s

(ii) Speed of waves:

$V = d/t$

$V = 0.06/0.21$

$V = 0.29 m/s$

Results:

Time period is 0.21 s and velocity is 0.29 m/s

10.9 At one end of a ripple tank 80 cm across, 5 Hz vibrator produces waves whose wavelength is 40mm. Find the time the waves need to cross the tank.

Solution:

Given data:

Length = l = 80 cm = 0.8 m

Frequency = f = 5Hz

Wavelength = λ = 40mm = 0.04 m

Required:

Time taken = t = ?

Calculation:

As we know that $v = f\lambda$

$V = (5)(0.04) = 0.2 m/s$

And

$v = d/t$

So, $t = d/v$

$t = 0.8/0.02$

$t = 4s$

Results:

Time taken is 4s.

10.10 What is the wavelength of the radio waves transmitted by an FM station at 90 MHz? Where 1M = 10^6, and speed of radio wave is $3 \times 10^8 ms^{-1}$.

Solution:

Given data:

Frequency = f = 90 MHz = 9×10^7 Hz

Speed = v = $3 \times 10^8 m/s$

Required;

Wave length = λ = ?

Formula:

As we know that

$v = f\lambda$

$\lambda = v/f$

Putting values:

Calculation:

$$\lambda = \frac{3\times10^8}{9\times10^7}$$

$$\lambda = \frac{3\times10^{8-7}}{9.0}$$

$\lambda = 3.333m$

Results:

Wavelength is 3.333m

UNSOLVED NUMERICAL PROBLEMS

Q.14.1 A current of 3mA is flowing through wire for 1 minute. What is the charge flowing through the wire?

Solution

Given Data

Current = I = 3mA

$I = 3 \times 10^{-3}$ A ($\therefore$ milli = m = 10^{-3})

Time = t = 1min

$T = 1 \times 60 = 60$ sec.

Required:

Charge = Q = ?

Formula

$$I = \frac{Q}{T}$$

$$\Rightarrow \quad Q = I \times t$$

$$Q = 3 \times 10^{-3} \times 60$$

$$Q = 180 \times 10^{-3} \text{ C Ans}$$

Q. 14.2 At 100,000 Ω how much current flows through your body if you touch the terminals of a 12-V battery? If your skin is wet, so that your resistance is only 1000 Ω, how much current would your receive form the same battery?

Solution:

Given Data

$R_1 = 100,000$

$V = 12$ volts

$R_2 = 1000\ \Omega$

Required

(a) $I_1 = ?$

(b) $I_2 = ?$

(a) **Formula:**

$$V = IR$$

$$\Rightarrow \quad I = \frac{V}{R}$$

$$I_1 = \frac{V}{R_1}$$

$$I_1 = \frac{12}{100{,}000}$$

$$I_1 = \frac{12}{10^5}$$

$$I_1 = 12 \times 10^{-5} A$$

$$I_1 = 1.2 \times 10^{-4} A \text{ Ans}$$

(b) **Formula:**

$$V = IR$$

$$\Rightarrow \quad I = \frac{V}{R}$$

$$I_2 = \frac{V}{R_2}$$

$$I_2 = \frac{12}{1000}$$

$$I_2 = 12 \times 10^{-3} A$$

$$I_2 = 1.2 \times 10^{-2} A \text{ Ans}$$

Q.14.3 The resistance of a conductor wire is 10 MΩ. If a potential difference of 100 volt is applied across its ends. Then find the value of current passing through it in mA.

Solution:

Given Data

Resistance = R = 10 MΩ = $10 \times 10^6 \Omega$ ($\because M = 10^6$)

Potential difference = V = 1000 volt

Required:

Current = I = ?

Formula

$$V = IR$$

$$\Rightarrow \quad I = \frac{V}{R}$$

$$I = \frac{100}{10 \times 10^6}$$

$$I = 10 \times 10^{-6}$$

$$I = 10^{-5} A$$

$$I = 10^{-2} \times 10^{-3} A$$

$$I = \frac{1}{10^2} mA$$

$$I = \frac{1}{100} mA$$

$$I = 0.01 mA$$

Q.14.4 By applying potential difference of 10 V across a conductor a current of 1.5A passes through it. How much energy would be obtained from the current in 2 minutes?

Solution:

Given Data

$V = 10$ volt

$I = 1.5$ Amp

Time $= t = 2\text{min} = 2 \times 60 = 120$ sec.

Required:

Energy $= W = ?$

Formula:

$W = I^2Rt$
$W = I(IR)t$
$W = I(V)t$
$W = (1.5)(10)(120)$
$W = 1800J$ **Ans.**

Q.14.5 Two resistances of 2kΩ 8kΩ are joined in series, if a 10V battery is connected across the ends of this combination, find following quantities.

(a) The equivalent resistance of the series combination.
(b) Current passing through each of the resistances.
(c) The potential difference across each resistance.

Solution:

Given Data

Value of first resistance	=	R1	=	$2K\Omega = 2\times10^3\Omega$
Value of second resistance	=	R2	=	$8K\Omega = 8\times10^3\Omega$
Potential of battery	=	V	=	10V

Required:

(a) Equivalent resistance in series	=	Re	=	?
(b)Current through each resistance	=	I	=	?
(c)Potential difference across first resistance	=	V1	=	?
Potential difference across second resistance	=	V2	=	?

Formula:

(a) Equivalent resistance $= R_e = R_1 + R_2$

$Re = 2K\Omega + 8K\Omega$

$= 10K\Omega$

Hence equivalent resistance is 10KΩ

(b) As the circuits is in series so same value of current will pass through each resistance.

$I = I_1 = I_2$

$= V = IRe$

By putting value

$$I = \frac{10}{10\times10^{3}}$$

$$I = 1\times10^{3}$$

$$I = 1mA$$

(c) Potential difference across first resistance $= V_1 = IR_1 = 1\times10^{-3}\times2\times10^{3}$

$$= 2V$$

Potential difference across second resistance $= V_2 = IR_2$

$$= 1\times10^{-3}\times8\times10^{3}$$

$$= 8V$$

Hence current through each resistance is 1mA and potential difference across first resistance is 2V and potential difference across second resistance is 8V.

Q.14.6 Two resistance of 6kΩ and 12kΩ are connected in parallel. A 6V battery is connected across its ends, find the values of the following quantities:

(a) Equivalent resistance of the parallel combination.

(b) Current passing through each of the resistances.

(c) Potential difference across each of the resistance.

Solution

Given Data

$$R_1 = 6K\Omega = 6\times10^{3}\Omega$$

$$R_2 = 12K\Omega = 12\times10^{3}\Omega$$

$$V = 6V$$

(a) Equalvalent resistance $R_e = ?$

(b) Potential differnce across $R_1 = V_1 = ?$

Potential differce across $R_2 = V_2 = ?$

(c) Current through resistance $R_1 = I_1 = ?$

Current through resistancer $R_2 = I_2 = ?$

(a) **Formula:**

$$\frac{1}{R_e} = \frac{1}{R_1}+\frac{1}{R_2}$$

$$\frac{1}{R_e} = \frac{1}{6\times10^{3}}+\frac{1}{12\times10^{3}}$$

$$= \frac{2+1}{12\times10^{3}}$$

$$= \frac{3}{12\times10^{3}}$$

$$\frac{1}{R_e} = \frac{1}{4\times10^{3}}$$

$$R_e = 4K\Omega$$

Hence equivalent resistance is $4K\Omega$

(b) As the circuit is parallel so potential difference across each resistance is equal to potential of battery,

$$V = V_1 = V_2 = 6V$$

(c) Quantity of current through first resistance $= I_1 = \frac{V_1}{R_1}$

$$= \frac{6}{6\times10^3}$$

$$= 1 \times 10^{-3}$$

$$I_1 = 1mA$$

Quantity of current though second resistance $I_2 = \frac{V_2}{R_2}$

$$= \frac{6}{12\times10^3}$$

$$= \frac{1}{2\times10^3}$$

$$= 0.5 \times 1^{-3}$$

$$I_2 = 0.5mA$$

Hence quantity of current is 1mA and 0.5 mA

Q.14.7 An electric bulb is marked with 220V, 100W. Find the resistance of the filament of the bulb. If the bulb is used 5 hours daily, find the energy in kilowatt-hour consumed by the bulb in one month (30 days).

Solution

Given Data

Voltage of bulb	=	V	=	220V
Power of bulb	=	P	=	100W
Daily use of bulb	=	t	=	5h
No. of days for bulb	=	30days		

Required:

Resistance of bulb filament	=	R	=	?
Energy consumed by bulb	E	=	?	

Formula

$$P = I^2R$$

But according to Ohm's law

$$I = \frac{V}{R}$$

So

$$P = \left(\frac{V}{R}\right)^2 \times R$$

$$P = \frac{V_2}{R_2} \times R$$

$$P = \frac{V_2}{R}$$

$$R = \frac{V_2}{P}$$

By putting values

$$R = \frac{(220)^2}{100}$$

$$R = \frac{48400}{100}$$

$$\mathbf{R = 484\Omega}$$

Time in 30 days $= 30 \times 5 = 150$ hours

Energy in kilowatt hour $= \frac{\text{Power (Watt)} \times \text{time (hour)}}{1000}$

$$= \frac{150 \times 100}{1000}$$

$$= 15\text{kWh}$$

$$= 15\text{kWh}$$

Q.14.8 An incandescent light bulb with an operating resistance of 95 Ω is labeled "150 W." Is this bulb designed for use in a 120-V circuit or a 220-V circuit? Explain with calculations. (it has been designed for 120 V as is evident form the power formula i.e.(P =VI). Ans.

Solutions:

Given Data

$R = 95\Omega$

Power $= P = 150$ W

Required:

For which voltage bulb is designed = ? (120V or 220V)

Formula:

$$P = I^2R$$

$$150 = I^2(95)$$

$$\Rightarrow I^2 = \frac{150}{95}$$

$$I^2 = 1.5784$$

$$\sqrt{I^2} = \sqrt{1.578}$$

$$I = 1.2565$$

$$V = IR$$

$$V = (1.2565)(95)$$

$$V = 119.37\text{volt}$$

$$V = 120\text{volt}$$

This bulb is designed for 120V

Q.14.9 A house is installed with

(a) 10 bulbs of 60 W each of which are used 5 hours daily.

(b) 4 fans of 75W each of which run 10 hours daily.

(c) One T.V. of 100 W which is used 2 hours daily.

(d) one electric iron of 1000 W which us used hours daily.

If the cost of one unit of electricity is Rs. 4. Find the monthly expenditure of electricity (one month = 30 days)

Solution

Given Data

Power of 10 bulbs	=	60×10	=	600 W
Power of 4 fans	=	75×4	=	300 W
Power of 1 iron	=	1000×1	=	1000W
Power of 1 T.V	=	100×1	=	100 W
Price of per unit	=	Rs. 4		

Required:

Monthly cost of electricity of house = ?

Formula:

$$\text{Energy consumed by bulb} = \frac{\text{Power (Watt)} \times \text{time (hour)}}{1000}$$

$$= \frac{600 \times 5 \times 30}{1000} = \frac{90000}{1000}$$

$$= 90 \text{ unit}$$

$$\text{Energy consumed by fans} = \frac{\text{Power (Watt)} \times \text{time (hour)}}{1000}$$

$$= \frac{300 \times 10 \times 30}{1000} = \frac{60 \times 1000}{1000}$$

$$= 60 \text{ Units}$$

$$\text{Energy consumed by T.V} = \frac{100 \times 5 \times 30}{1000} = \frac{100 \times 150}{1000}$$

$$= 15 \text{ units}$$

Total consumed energy in units = $90 + 90 + 60 + 15$

= 255 Units

Price of electricity = $255 \times 4 = 1020$ Rs.

Hence total price of electricity is 1020 rupees.

Q. 14.10 A 100 W lamp bulb and a 4 kW water heater are connected to a 250 V supply. Calculate

(a) The current which flows in each appliance and

(b) The resistance of each appliance when in use

Solution:

Given Data

Power = $P_1 = 100W$ (lamp)

Power = $P_2 = 4kW$ (heater)

$P_2 = 4 \times 10^2 W$

$V = 250$ Volts

Required:

(a) $I_1 = ?$

$I_2 = ?$

(b) $R_1 = ?$

$R_2 = ?$

Formula:

Current in Lamp; (I_1)

$P = VI_1$

$P_1 = VI_1$

$$\Rightarrow \quad I_1 = \frac{P_1}{V_1}$$

$$I_1 = \frac{100}{250}$$

$I_1 = 0.4A$ Ans.

(a) Current in heater; (I_2)

$P = VI$

$P_2 = VI_2$

$$\Rightarrow I_2 = \frac{P_2}{V}$$

$$I_2 = \frac{4 \times 10^3}{250}$$

$I_2 = 0.016 \times 10^3 A$

$I_2 = 16A$ Ans.

(b) Resistance of Lamp; (R_1)

$V = IR$

$V = I_1 R_1$

$250 = (0.4)R_1$

$$\frac{250}{0.4} = R_1$$

$625\Omega = R_1$

$R1 = 625\Omega$ Ans.

(c) Resistance of heater; (R_2)

$$V = IR$$
$$V = I_2R_2$$
$$250 = 16(R_2)$$
$$\frac{250}{16} = R_2$$
$$15.625\Omega = R_2 \text{ Ans.}$$

Q.14.11 A resistor of resistance 5.6 Ω is connected across a battery of 3.0 V by means of wire of negligible resistance. Current of 0.5 A passes through the resistor. Calculate the

(a) power dissipated in the resistor

(b) total power produced by the battery

(c) Give the reason of difference between these two quantities.

Solution: Given that,

Resistance $R = 5.6\Omega$

Voltage $V = 3V$

Current $I = 0.5A$

Required:

(a) Power dissipated $P = ?$

(b) power produced by the battery $P = ?$

(c) Why these two quantities differ = ?

Calculations:

Using the formula

$P = VI$

We know that

$V = IR$

$P = I^2R$

By putting the values

$P = (0.5A)^2 (5.6\Omega)$

$= 0.25A \times 5.6\Omega$

$P = 1.4W$ Ans.

(b) Using the formula

$P = VI$

By putting the values

$P = 3V \times 0.3A$

$P = 1.5$ W Ans.

(c) Because some power is lost by the internal resistance of the battery

NUMERICAL PROBLEMS

15.1 **A transformer is needed to convert a mains 240 V supply into a 12V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil.**

Solution:

Given Data:

$V_p = 240$ V

$V_s = 12$V

$N_p = 2000$

Required: $N_s = ?$

Formula:

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

$$\mathbf{Ns = \frac{Vs \times Np}{Vp} = \frac{12 \times 2000}{240} = 100}$$

15.2 **A step-up transformer has a turn ratios of 1:100.An alternating supply of 20V is connected across the primary coil. What is secondary voltage?**

Solution:

Given Data:

$N_p : N_s = 1:100$

$V_p = 20V$

Required :

$\mathbf{V_s = ?}$

Formula

$$\frac{N_p}{N_s} = \frac{1}{100}$$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$Vs = \frac{N_s \times V_p}{N_p} = \frac{100}{1} \times 20$$

$V_s = 2000$ Volt Ans

15.3 **A step – down transformer has a turns ratio of 1:100. An ac voltage of amplitude 170V is applied to the primary. If the current in the primary is 10 mA, what is the current in the secondary?**

Solution:

Given Data:

$$N_s : N_p = 1:100$$

$$\frac{N_s}{N_p} = \frac{1}{100}$$

$$V_p = 170\text{v}$$

$$\mathbf{I_p = 1mA = 1 \times 10^{-3}\ A}$$

Required

$$I_s = ?$$

Formula

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$V_s = \frac{N_s}{N_p} \times V_p$$

$$= \frac{1}{100} \times 170 = 1.7V$$

For an ideal transformer

Power of primary =Power of secondary

$$P_p = P_s$$

$$I_p V_p = I_s V_s$$

$$\frac{I_p V_p}{V_s} = I_s$$

$$\frac{1 \times 10^{-3} \times 170}{1.7} = I_s$$

$$\mathbf{0.1\ A = I_s \Rightarrow I_s = 0.1A\ Ans}$$

15.4 **A transformer, designed to convert the voltage from 240 V a.c. mains to 12V, has 4000 turns on the primary coil. How may turns should be on the secondary coil? If the transformer were 100% efficient, what current would flow through the primary coil when the current in the secondary coil was 0.4A?**

Solution:

Given Data:

$$V_p = 240V$$

$$V_s = 12V$$

$$N_p = 4000$$

Required: $N_s = ?$

Formula:

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

$$N_s = \frac{V_s \times N_p}{V_p} = \frac{12 \times 4000}{240}$$

$N_s = 200$ Ans

$I_p = ?$

$I_s = 0.4A$

$P_p = P_s$

$I_p V_p = I_s V_s$

$$I_p = \frac{I_s V_s}{V_p} = \frac{0.4 \times 12}{240}$$

$\mathbf{I_p = 0.02\ A}$

15.5 A power station generates 500 MW of electrical power which is fed to a transmission line. What current would flow in the transmission line if the input voltage is 250 kV?

Solution:

Given Data:

$V = 250 \times 10^3 V$

Power = $P = 500 \times 10^6 W$

Required: $I = ?$

Formula: $P = IV$

$$\frac{P}{V} = I$$

$$\frac{500 \times 10^6}{250 \times 10^3} = I$$

$2 \times 10^3 A = I \quad \Rightarrow \quad I = 2KA$ Ans

15.6 The diagram shows a wind turbine which a 150 kW generator with an output voltage of 1000V. The voltage is increased by transformer T_1 to 10 000 V for transmission to a town 5 km away through power lines with a total resistance of 2Ω. Another transformer, T, at the town reduces the voltage to 250V. Assume that the transformers are 'Ideal' when the system is running at full power: (Figure from the textbook page 143)

Solution:

Given Data:

Power = $P = 150$ k W

$P = 150 \times 10^3 W$

At T_1 $\quad V_p = 10000$ V

$R = 2\Omega$

At T_2 $\quad V_s = 250$

NUMERICAL PROBLEMS

11.1 A normal conversation sound intensities of about 3.0 x 10^{-6} Wm^{-2}. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB?

(a) **Given Data**

Intensity of sound = $I = 3.0\times10^{-6} wm^{-2}$

Intensity of faintest sound = $I_o = 10^{-12} wm^{-2}$

Required

Intensity level = $L - L_o$ = ?

Solution

As we know that

$$L - L_o = 10 \log \frac{I}{I_o} dB$$

$$= 10 \log \frac{3\times10^{-6}\ wm^{-2}}{10^{-12}\ wm^{-2}} dB$$

$$L - L_o = 10 \log\left(\frac{3\times10^{-6}}{10^{-12}}\right)$$

$$= 10\log\left(3\times10^{-6+12}\right) dB$$

$$= 10\log\left(3\times10^{6}\right) dB$$

$$= 10\times6.47 dB$$

$$= 64.7 \text{ dB}$$

(b) **Given Data**

Intensity level $L - L_o$ = 100 dB

Intensity of faintest audible sound = $I_o = 10^{-12} wm^{-2}$

Required

Intensity of given sound = I = ?

Solution

We know that

$$L - L_o = 10 \log \frac{I}{I_o} \text{ dB}$$

$$100 \cancel{dB} = 10 \log \frac{I}{10^{-12} \text{ wm}^{-2}} \cancel{dB}$$

$$\Rightarrow \quad \frac{100}{10} = \log \frac{I}{10^{-12} \text{ wm}^{-2}}$$

$$10 = \log \frac{I}{10^{-12}}$$

$$10 = \log 10^{12} \times I$$

Taking antilog on both sides

$$\text{Antilog } 10 = \text{Antilog} \left[\log \left(10^{12} \times I \right) \right]$$

$$1 \times 10^{10} = 10^{12} I$$

$$\frac{1 \times 10^{10}}{10^{12}} = I$$

$$I = 1 \times 10^{-2}$$

$$I = 0.01 Wm^{-2}$$

11.2 If at Anarkali bazaar Lahore, the sound level is 80 dB, what will be the intensity level of sound there?

Given Data

Sound level = $L - L_o$ = 80 dB

Intensity of faintest audible sound = $I_o = 10^{-12} \text{wm}^{-2}$

Required Intensity of sound = I = ?

Solution We know that

$$L - L_o = 10 \log \frac{I}{I_o} \text{ dB}$$

$$80 \cancel{dB} = 10 \log \frac{I}{10^{-12} \text{ wm}^{-2}} \cancel{dB}$$

$$\frac{80}{10} = \log \frac{I}{10^{-12} \text{ wm}^{-2}}$$

$$8 = \log \left(10^{12} \times I \right)$$

Taking antilog on both sides

$$\text{Antilog } 8 = \text{Antilog} \left[\log \left(10^{12} \times I \right) \right]$$

$$10^{8} = 10^{12} \times I$$

$$\frac{10^{8}}{10^{12}} = I$$

$$I = 10^{8-12}$$

$$I = 10^{-4} Wm^{-2}$$

11.3 **At a particular temperature, the speed of sound in air is $330ms^{-1}$. If the wavelength of a note is 5cm, calculate the frequency of the sound wave. Is this frequency lies in the audible range of the human ear?**

Given Data

Speed of sound = $v = 330\ ms^{-1}$

Wavelength = λ = 5cm

$$= \frac{5}{100} m = 0.05m$$

Required

Frequency = f = ?

Solution

We know that

$$v = f\lambda$$

$$\Rightarrow \quad f = \frac{v}{\lambda}$$

$$= \frac{330\,ms^{-1}}{0.05\,m}$$

$$= 6600s^{-1} \qquad s^{-1} = Hz$$

$$f = 6.6\times10^{3}\ Hz$$

$\because$ yes this frequency lies in the range of human ear.

11.4 **A doctor counts 72 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.**

Given Data

No of heartbeats = n = 72

Time = t = 1 min

= 1 × 60sec = 60sec

Required

Frequency = f = ?

Time period = T = ?

Solution

We know that

$$f = \frac{n}{t}$$

$$= \frac{72}{60\,sec}$$

$$= 1.2\ s^{-1} \qquad s^{-1} = Hz$$

$$= 1.2\ Hz$$

As

$$T = \frac{1}{f}$$

$$= \frac{1}{1.2\,s^{-1}}$$

$$T = 0.833\ sec.$$

11.5 A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5s later. The speed of sound in a sea water is 1500 ms^{-1}. Find the depth of the sea at this position.

Given Data:

Time taken = t = 1.5 s

Speed = v = 1500ms^{-1}

Required:

Depth of sea water = h =

Solution:

As we know that

S = vt

= (1500) (1.5)

= 2250m

For hearing echo, the minimum depth from sea bed to ship must be half of this depth (2250m)

$$h = \frac{S}{2}$$

$$= \frac{2250}{2}$$

$$= h = 1125m$$

11.6 A student clapped his hands near a cliff and heard the echo after 5s. What is the distance of the cliff from the student if the speed of the sound, v is taken as 346 ms^{-1}?

Given data:

Time taken = t = 5s

Speed = v = 346 ms^{-1}

Required:

Distance = d = ?

Solution:

As we know that

S = vt

= 346 x 5

S = 1730 m

For hearing echo, the minimum distance from obstacle to the source of sound must be half of this distance (1730m).

$$d = \frac{S}{2}$$

$$d = \frac{1730}{2}$$

d = 865 m

11.7 A ship sends out ultrasound that returns from the seabed and is detected afte 3.42s. If the speed of ultrasound through seawater is 1531 ms^{-1}, what is the distance of the seabed from ship?

Given data:

Time taken = t = 3.42S

Speed = v = 1531 ms^{-1}

Required:

Depth of sea water = h = ?

Solution:

As we know that

S = vt

= 1531 x 3.42

= 5236.02 m

For hearing echo, the minimum depth from sea ship must be half of this distance (5236.02m)

$$h = \frac{s}{2}$$

$$= \frac{5236.02}{2}$$

$$h = 2618m$$

11.8 The highest frequency sound humans can hear is about 20,000 Hz. What is the wavelength of sound in air at this frequency at temperature of 20°C? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 20°'C is 343 ms^{-1}.

Given Data

Highest frequency = f_1 = 20,000 Hz

Lowest frequency = f_2 = 20 Hz

Speed of sound = v = 343 ms^{-1}

Required

Wavelength of highest frequency = λ_1 = ?

Wavelength of lowest frequency = λ_2 = ?

Solution:

We know that $v_1 = f_1\lambda_1$

$$\Rightarrow \lambda_1 = \frac{v}{f_2}$$

$$= \frac{343\,ms^{-1}}{20,000\,s^{-1}}$$

$$\lambda_1 = 0.01715\ m = 1.7 \times 10^{-2}\ m$$

As

$$V = f_2 \lambda_2$$

$$\Rightarrow \quad \lambda_2 = \frac{v}{f_2}$$

$$= \frac{343\,ms^{-1}}{20\,s^{-1}}$$

$$= 17.15\ m$$

$$\boldsymbol{\lambda_2 = 17.15\ m}$$

11.9 A sound wave has frequency of 2 kHz and wavelength 35cm. How long will it take to travel 1.5 km?

Given Data:

Frequency = $f = 2$ KHz

$= 2 \times 10^3$ Hz

Wavelength = $\lambda = 35$ cm $= \frac{35}{100}$ m $= 0.35$m

Distance = $s = 1.5$ Km $= 1.5 \times 1000$m $= 1500$ Km

Required:

Time = t = ?

Solution:

We know that

$$V = f\lambda$$

$$= 2 \times 10^3\ Hz \times 0.35\ m \qquad Hz = s^{-1}$$

$$= 700\ ms^{-1}$$

As

$$S = v \times t$$

$$1500\ m = 700\ ms^{-1} \times t$$

$$t = \frac{1500\,m}{700\,ms^{-1}}$$

$$= 2.1\ sec$$

NUMERICAL PROBLEMS

12.1 An object 10.0 cm in front of a convex mirror forms an image 5.0 cm behind the mirror. What is the focal length of the mirror?

Solution:

Given that:

Distance of object $p = 10$ cm

Distance of image $q = -5$ cm (For convex mirror)

To Find:

Focal length $f = ?$

Calculations: Using the formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

By putting the values

$$\frac{1}{f} = \frac{1}{10cm} - \frac{1}{5cm}$$

$$= \frac{1-2}{10cm}$$

$$\frac{1}{f} = \frac{-1}{10cm}$$

$f = -10$ cm **Ans.**

12.2 An object 30.0 cm tall is located 10.5 cm from a concave mirror with focal length 16.0cm. (a) Where is the image located) (b) How high is it?

Solution: Given that,

Object height $h_o = 30$ cm

Distance of object $p = 10.5$ cm

Focal length $f = 16$ cm

To Find:

(a) Distance of image $q = ?$

(b) Image height $h_i = ?$

Calculations: (a) Using the formula

$$\text{Or } \frac{1}{f} = \frac{1}{q} + \frac{1}{p}$$

By putting the values

$$\frac{1}{q}=\frac{1}{16cm}-\frac{1}{10.5cm}$$

Or $$\frac{1}{q}=\frac{1}{16cm}-\frac{10}{105cm}$$

$$=\frac{105-160}{(16)(105)cm}$$

$$=\frac{-55}{(16)(105)cm}$$

q= 30.54 cm **Ans.**

(b) we know that

$$\frac{image\ hegith}{object\ height}=\frac{q}{p}$$

or $$\frac{h_i}{h_o}=\frac{q}{p}$$

by putting the values

$$\frac{h_i}{30cm}=\frac{30.54cm}{10.5cm}$$

$$h_i=\frac{30.54cm}{10.5cm}\times 30cm$$

h_i = 87.26 cm Ans.

12.3 An object and its image in a concave mirror are of the same height, yet inverted, when the object is 20.0 cm form the mirror. What is the focal length of the mirror?

Solution: given that,

Distance of object p = 20 cm

Distance of image q =20 cm

To find: focal length f =?

Calculations: using the formula

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

By putting the values

$$\frac{1}{f}=\frac{1}{20cm}+\frac{1}{20cm}$$

$$= \frac{1+1}{20\,cm}$$

$$= \frac{2}{20\,cm}$$

$$f = \frac{20\,cm}{2}$$

f = 10 cm **Ans.**

12.4 Find the focal length of a mirror that form an image 5.66 cm behind a mirror of an object placed at 34.4 cm in front of the mirror

Solution **Given Data:**

Distance of the image form the mirror = q = 5.66

Distance of object form the mirror = q = 34.4 cm

Required Data:

Find out the focal length of the mirror = ?

Formula: $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

Calculations: By using the above formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

As the image is formed behind the mirror, so it would be convex mirror, so q and f are all negative.

$q = -5.66$ cm

$p = +34.4$ cm

By substituting values in above equation, we get;

$$\frac{1}{f} = -\frac{1}{5.66} + \frac{1}{34.4}$$

$$\frac{1}{f} = -0.177 + 0.029$$

$$\frac{1}{f} = -0.148$$

$$f = -6.77cm$$

12.5 An image of a statue appears to be 11.5 cm behind a convex mirror with focal length 13.5 cm. find the distance form the statue to the mirror.

Solution: Given that,

Distance of image q = -11.5 cm (For convex mirror)

Focal length f = 13.5 c

To Find: Distance of object p = ?

Calculations: Using the formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

Or $$\frac{1}{p} = \frac{1}{f} + \frac{1}{q}$$

By putting the values

$$\frac{1}{p} = \frac{1}{13.5\,cm} + \frac{1}{11.5\,cm}$$

$$= \frac{11.5 + 13.5}{(13.5)(11.5)cm}$$

$$= \frac{25}{155.25\,cm}$$

$$p = \frac{155.25\,cm}{25}$$

$p = 6.21$ cm **Ans.**

12.6 An image is produced by a concave mirror of focal length 8.70cm. The object is 13.2 cm tall and at a distance 19.3 cm from the mirror. (a) Find the location and height of the image. (b) Find the height of the image produced by the mirror if the object is twice as far from the mirror.

Solution: Given that,

Focal length $f = 8.70$ cm

Object height $h_o = 13.2$ cm

Distance of object $p = 19.3$ cm

To Find:

(a) (i) Location of image q = ?

(ii) Height of image h_o = ?

Calculation: (i) Using the formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

Or $$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

$$= \frac{1}{8.7\,cm} + \frac{1}{19.3\,cm}$$

13.1.7 A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Solution: Given that,

Charge $Q = 0.06\ C$

Voltage $V = 9V$

To Find: Capacitance $C = ?$

Calculations: Using the formula

$$Q = CV$$

Or $$C = \frac{Q}{V}$$

By putting the values

$$C = \frac{0.06C}{9v}$$

$C = 6.67 \times 10^{-3}$ F **Ans.**

13.1.8 A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Solutions: Given that

Charge $= Q = 0.03\ C$

Voltage $V = 6V$

To Find: Voltage to hold 2C of charge $V = ?$

Calculations: Since

$$0.03\ C = 6V$$

Or $$1C = \frac{6V}{0.03}$$

Therefore,

$$2C = \frac{6V}{0.03} \times 2$$

$$= \frac{1200V}{3}$$

$V = 400$ V **Ans.**

12.7 Nabeela uses a concave mirror when applying makeup. The mirror has a radius of curvature of 38.0 cm. (a) what is the focal length of the mirror? (b) Nabeela is located 50cm from the mirror. Where will her image appear? (c) Will the image be upright or invited?

Solution: Given that,

Radius of curvature R = 38 cm

Distance of object p = 50 cm

To Find

(a) Focal length $f = ?$

(b) Distance of image $q = ?$

(c) Nature of image = ?

Calculation (a) Using the formula

$$f = \frac{R}{2}$$

or

$$f = \frac{38\,cm}{2}$$

$$f = 19\ cm$$ **Ans**

(b) Using the formula

$$\frac{1}{f} = \frac{1}{q} + \frac{1}{p}$$

Or

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

$$\frac{1}{q} = \frac{1}{19\,cm} - \frac{1}{50\,cm}$$

$$= \frac{50 - 19}{(19)\,(50)\,cm}$$

$$= \frac{31}{950\,cm}$$

$$q = \frac{950\,cm}{31}$$

$$q = 30.64\ cm$$ **Ans**

(c) Because magnification $m = \frac{q}{p}$ is positive, so image will be upright.

12.8 An object 4cm high is placed at a distance of 12cm form a convex lens of focal length 8cm. Calculate the position and size of the image. Also state the nature of the image.

Solution: Given that,

Height of object $h_o = 4cm$

Distance of object $p = 12\ cm$

Focal length $f = 8\ cm$

To Find

(i) Position of image $q = ?$

(ii) Size of image $h_i = ?$

(iii) Nature f the image $= ?$

Calculations: (i) Using the formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

or

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

$$\frac{1}{q} = \frac{1}{8\,cm} - \frac{1}{12\,cm}$$

$$= \frac{12 - 8}{(8)(12)cm}$$

$$= \frac{4}{96\,cm}$$

$$q = \frac{96\,cm}{4}$$

$q = 24\ cm$ **Ans.**

(ii) We know that

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or

$$h_i = \frac{q}{p} \times h_o$$

By putting the values

$$h_i = \frac{24\,cm}{12\,cm} \times 4cm$$

$h_i = 8\ cm$ **Ans**

(iii) Since the lens in convex and size of image is larger than the size of the object, therefore, image formed is real, inverted and magnified

12.9 An object 10cm high is placed at a distance of 20cm from a concave lens of focal length 15cm high is placed at a instance of 20 cm from a concave lens of focal length 15cm. Calculate the position and size of the image. Also state the nature of the image.

Solution: Given that.

Size of object $h_o = 10$ cm
Distance of object $p = 20$ cm
Focal length $f = -15$ cm (for concave lens)

To Find

(i) Politico of image $q = ?$
(ii) Size of image $h_i = ?$
(iii) Nature of image $= ?$

Calculations: (i) Using the formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

or

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

$$\frac{1}{q} = \frac{1}{15\,cm} - \frac{1}{20\,cm}$$

$$= \frac{-4-3}{60\,cm}$$

$$= \frac{-7}{60\,cm}$$

$$q = -\frac{60}{7}\,cm$$

$$= -.57\text{ cm}$$ **Ans.**

(ii) We know that

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $$h_i = \frac{q}{p} \times h_o$$

By putting the values

$$h_i = \frac{-8.57\,cm}{20\,cm} \times 10cm$$

$h_i = 4.28$ cm **Ans**

(iii) Since the lens is concave and object is larger in size than the size of the image, therefore, the image in virtual, eract and diminished.

12.10 A convex lens of focal length 6cm is to be used to form a virtual image three times the size of the object. Where must the lens be placed?

Solution: Given that,

Focal length $f = 6$ cm (For virtual image)
Distance of image $q = 3p$

To Find: Distance of object p = ?

Calculations: Using the formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

By putting the valuses

$$\frac{1}{6\,cm} = \frac{1}{p} + \frac{1}{3p}$$

$$\frac{1}{6\,cm} = \frac{3-1}{3p}$$

$$\frac{1}{6\,cm} = \frac{2}{3p}$$

Or $3p = 12\,cm$

$$p = \frac{12\,cm}{3}$$

$p = 4cm$ **Ans.**

12.11 A ray of light from air is incident on a liquid surface at an angle of incidence 35°. Calculate the angle refraction if the refractive index of the liquid is 12.5. Also calculate the critical angle between the liquid air inter-face.

Solution: Given that,

Angle of incidence $i = 35°$

Refractive index $n = 1.25$

To Find

(i) Angle of refraction r = ?

(ii) Critical angle C = ?

Calculation: (i) Using Snell's law

$$\frac{\sin i}{f} = n$$

$$\text{Or } \sin r = \frac{\sin i}{n}$$

By putting the values

$$\sin r = \frac{\sin(35°)}{1.25}$$

$$\sin r = \frac{0.57}{1.25}$$

$$= 0.456$$

$$r = \sin^{-1}(0.456)$$

$$r = 27.13°$$

(ii) For critical angle. We know that

$$\sin C = \left(\frac{1}{n}\right)$$

or $C = \sin^{-1}\left(\frac{1}{n}\right)$

By putting the values

$$C = \sin^{-1}\left(\frac{1}{1.25}\right)$$

$$= \sin^{-1}(0.8)$$

$C = 52.13^\circ$ **Ans**

12.12 The power of a convex lens is 5D. At whit distance the object should be placed from the lens so that its real and 2 times larger image is formed.

Solution: Given that

Power of the lens p = 5D

Size of image q = 2p

To Find: Distance of object p = ?

Calculations: Using the formula

Power of lens $p = \frac{1}{f}$

or $5 = \frac{1}{f}$

or $f = \frac{1}{5}$

or $f = 0.2\text{m}$

$$= \frac{2}{10} \times 100 \text{ cm} = 20 \text{ cm}$$

Now using the formula

$$\frac{1}{f} = \frac{1}{q} + \frac{1}{p}$$

By putting the values

$$\frac{1}{20\text{cm}} = \frac{1}{p} + \frac{1}{2p}$$

$$\frac{1}{20\text{cm}} = \frac{2+1}{2p}$$

$$\frac{1}{20\text{cm}} = \frac{3}{2p}$$

$$2p = 60 \text{ cm}$$

$$p = \frac{60\text{cm}}{2}$$

$p = 30$ cm **Ans.**

NUMERICAL PROBLMES

13.1.1 The charge of how many negatively charged particles would be equal to $100\mu C$. Assume charge on one negative particle is $1.6\times10^{-19}C$?

Solution: Given that,

Total Charge Q = 100 μC $= 100 \times 10^{-6}$ C

Charge on an electron $e = 1.6 \times 10^{-19}$ C

To find: No. of negatively charged particles n = ?

Calculations: Using the formula

$$Q = ne$$

Or
$$n = \frac{Q}{e}$$

By putting the values

$$n = \frac{100\times10^{-6}C}{1.6\times10^{-19}C}$$

$$= \frac{10^{2}\times10^{-6}\times10^{19}}{1.6}$$

$$= \frac{10^{-6} \times 10^{21}}{1.6}$$

$$= \frac{1}{1.6} \times 10^{15}$$

$$= \frac{1}{16} \times 10^{16} = 0.0625 \times 10^{15}$$

$n = 6.25 \times 10^{13}$ **Ans**

13.1.2 Two point charges $q_1 = 10\mu C$ and $q_2 = 5\mu C$ are placed at a distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.

Solution: Given that

First point charge = $q_1 = 10\mu C = 10 \times 10^{-6} = 1 \times 10^{-5} C$

Second point charge = $q_2 = 5\ \mu C = 5 \times 10^{-6}\ C$

Distance $r = 150\ cm = \frac{150cm}{100} = 1.5\ m$

Proportionality constant = $k = 9 \times 10^9\ Nm^2\ C^{-2}$

To Find

(i) Magnitude of Coulomb's force F = ?

(ii) Direction of Coulomb's force = ?

Calculations: According to Coulomb's law

$$F = k\frac{q_1 q_2}{r^2}$$

By putting the values

$$F = \frac{9 \times 10^9 Nm^2C^{-2} \times 1 \times 10^{-5} C \times 5 \times 10^{-6} C}{(1.5m)^2}$$

$$= \frac{9 \times 10^9 Nm^2 \times 10^{-5} \times 5 \times 10^{-6}}{2.25m^2}$$

$$= \frac{45 \times 10^{-2} N}{2.25}$$

$$= \frac{45}{225} N$$

$F = 0.2\ N$ **Ans**

The direction of coulomb's force is direction of repulsion

13.1.3 The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m part. Find the value of each charge.

Solution: Given that,

Force = F = 0.8 N

Distance between the charges r = 0.1 m

Proportionality constant = k = $9 \times 10^9\ Nm^2C^{-2}$

To Find: Value of each charger = q = ?

Calculations: Using Coulomb's law

$$F = \frac{kq_1q_2}{r^2}$$

Since the charges are identical, therefore, $q_1 = q_2 = q$, thus

$$F = k\frac{q^2}{r^2}$$

Or $\quad F \times r^2 = 9 \times 10^9\ Nm^2\ C^{-2} \times q^2$

Or $\quad q^2 = \dfrac{F \times r^2}{9 \times 10^9\ Nm^2C^{-2}}$

By putting the values

$$q^2 = \frac{0.8N \times (0.1m)^2}{9 \times 10^9\ Nm^2\ C^{-2}}$$

$$= \frac{0.8 \times 0.01}{9 \times 10^9} C^2$$

$$= \frac{0.008}{9 \times 10^9} C^2$$

$$q = \sqrt{\frac{0.008 \times 10^{-9}}{9}}\ C$$

$q = 9.4 \times 10^{-7}$ C Ans

13.1.4 Two charges repel each other with a force of 0.1 N when they are 5cm apart. Find the forces between the same charges when they are 2 cm apart.

Solution: Given that,

Force F = 0.1 N

Distance between the charges r = 5 cm = $\frac{5}{100}$ m = 0.05 m

To Find: Forces between the charge when they are 2 cm or 0.02 m apart F = ?

Calculations: According to coulomb's law.

$$F = K\frac{q q}{r^2}$$

By putting the values

$$0.1\ N = 9 \times [illegible]\ Nm^2\ C^{-2} \times \frac{q q}{(0.05m)^2}$$

Or $\quad q_1q_2 = \frac{0.1\times(0.05)^2}{9\times10^9}C^2$

Now force between the charges

$$F = k\frac{q_1q_2}{r^2}$$

By putting the values

$$F = 9\times10^9\,Nm^2C^{-2}\times\frac{(0.1)\times(0.05)^2C^2}{9\times10^9}\times\frac{1}{(0.02m)^2}$$

$$= \frac{(0.1)\times(0.05)^2}{(0.02)^2}N$$

$F = 0.62$ N **Ans.**

13.1.5 The potential lat a point in an electric field is 10^4 V. If a charge of $+100\mu C$ is brought from infinity to this point. What would be the amount of work done on it?

Solution: Given that,

Electric potential V $= 10^4$ V

Charge q $= +100\ \mu C = 100\times10^{-6}\ C = 1\times10^{-4}\ C$

To Find: Work done W = ?

Calculations: Using the formula

$$V = \frac{W}{q}$$

Or $\quad W = qV$

By putting the values

$W = 10^{-4}\ C\times10^4\ C$

$W = 1J$ **Ans.**

13.1.6 A point charge of +2C is transferred from a point at potential 100V to a point at potential 50V, what would be the energy supplied by the charge?

Solution: Given that,

Charge q $= +2C$

Potential at point A V_A $= 100$ V

Potential at point B V_B $= 50$ V

To Find: Energy supplied by the charge E = ?

Calculations

Using the formula

$$E = q(V_A - V_B)$$

By putting the values

$E = 2C(100V - 50V)$

$E = 100$ J **Ans.**

13.1.7 A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Solution: Given that,

Charge $Q = 0.06\ C$

Voltage $V = 9V$

To Find: Capacitance $C = ?$

Calculations: Using the formula

$$Q = CV$$

Or $$C = \frac{Q}{V}$$

By putting the values

$$C = \frac{0.06C}{9v}$$

$C = 6.67 \times 10^{-3}$ F **Ans.**

13.1.8 A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Solutions: Given that

Charge $= Q = 0.03\ C$

Voltage $V = 6V$

To Find: Voltage to hold 2C of charge $V = ?$

Calculations: Since

$$0.03\ C = 6V$$

Or $$1C = \frac{6V}{0.03}$$

Therefore,

$$2C = \frac{6V}{0.03} \times 2$$

$$= \frac{1200V}{3}$$

$V = 400$ V **Ans.**

13.1.9 Two capacitors of $6\mu F$ and $12\mu F$ are connected in series with 12V battery. Find the equivalent capacitance of the combination. Find the charge and potential difference across each capacitor.

Solution: Given that,

Capacitance = $C_1 = 6\ \mu F = 6 \times 10^{-6} F$

Capacitance = $C_2 = 12\ \mu F = 12 \times 10^{-6} F$

Voltage = V = 12 V

To Find

(i) Equivalent capacitance $C_{eq} = ?$

(ii) Charge on each capacitor $Q = ?$

(iii) Potential difference across one capacitor $V_1 = ?$

Potential difference across second capacitor = $V_2 = ?$

Calculations: (i) Since the capacitors are connected in series, therefore, equivalent capacitance will be

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

By putting the values

$$\frac{1}{C_{eq}} = \frac{1}{6\mu F} + \frac{1}{12\mu F} = \frac{2+1}{\mu F}$$

$$\frac{1}{C_{eq}} = \frac{3}{12\mu F}$$

Or $$C_{eq} = \frac{12\mu F}{3}$$

$$C_{eq} = 4\mu F \textbf{ Ans.}$$

(ii) Since the capacitor are connected in series, therefore, charge on capacitor will be

$$Q = CV$$

Or $$Q = 4 \times 10^{-6}\ F \times 12V$$

$$Q = 48 \times 10^{-6}\ FV$$

$$Q = 48\ \mu C \textbf{ Ans.}$$

(iii) Potential difference across capacitor of capacitance C_1 will be

$$Q = C_1 V_1$$

Or $$V_1 = \frac{Q}{C_1}$$

Or $V_1 = \dfrac{48\mu C}{6\mu F} = 8V$ **Ans.**

Similarly, potential difference across capacitor of capacitance C_2 will be

$$Q = C_2V_2$$

Or $V_2 = \dfrac{Q}{C_2}$

Or $V_2 = \dfrac{48\mu C}{12\mu F} = 4V$ **Ans.**

13.1.10 Two capacitors of capacitances $6\mu F$ and $12\mu F$ are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Solution: Given that,

Capacitance $= C_1 = 6\mu F$

Capacitance $= C_2 = 12\mu F$

Voltage $= V = 12V$

To Find

(i) Equivalent capacitance $C_{eq} = ?$

(ii) Charge on one capacitor $Q_1 = ?$

(iii) Charge on second capacitor $= Q_2 = ?$

(iv) Potential difference across each capacitor $V = ?$

Calculations: (i) Since the capacitors are connected in parallel, therefore, equivalent capacitance will be

$$C_{eq} = C_1 + C_2$$

$$= 6\mu F + 12\mu F$$

$C_{eq} = 18\mu F$ **Ans.**

(ii) Charge on capacitor C_1 will be

$$Q_1 = C_1V$$

Or $Q_1 = 6\mu F \times 12V$

$Q_1 = 72\mu C$ **Ans.**

(iii) Charge on capacitor C_2 will be

$$Q_2 = C_2V$$

$$Q_2 = 12\mu F \times 12V$$

$Q_2 = 144\mu C$ Ans.

(iv) Since the capacitors are connected in parallel, therefore, potential difference across each capacitor will be 12V.